Ryan Hydroelectric Facility,
Powerhouse
Great Falls Vicinity
Cascade County
Montana

HAER No. MT-98-A

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PHOTOGRAPHS
HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
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HISTORIC AMERICAN ENGINEERING RECORD

RYAN HYDROELECTRIC FACILITY, POWERHOUSE

HAER No. MT-98-A

I. INTRODUCTION

Location:	The Ryan Hydroelectric Facility is on the Missouri River approximately seven miles northeast of Great Falls, Montana. The powerhouse stands on the north bank of the river about 150 downstream from the dam. It and several other resources at Ryan contribute to the significance of the Great Falls Hydroelectric Facilities Historic District.
Quad:	Morony Dam, Mont.
UTM:	Zone 12: 490880 Easting; 5268300 Northing
Date of Construction:	1915-1916
Present Owner:	The Montana Power Company
Present Use:	House for hydroelectric generating equipment
Significance:	The Great Falls Hydroelectric Facilities Historic District is significant for its association with the industrial development of Montana and the consolidation of most of the state's electric industry into The Montana Power Company. The district is also associated with John D. Ryan, a promoter of hydroelectric development at Great Falls. The powerhouse at Ryan contributes to the significance of the district as a well-preserved example of industrial architecture common from around the turn of the century until mid-1910s. The hydraulic and generating equipment installed in the powerhouse are also representative of hydroelectric plant technologies of the period.
Historian:	Mary McCormick Renewable Technologies, Inc. Butte, Montana 59701 September 1996

II. HISTORY

A. INTRODUCTION

This HAER report only documents the govemance installed in the Ryan Powerhouse. This system is original to the 1915-16 hydroelectric plant. Designed and manufactured by the Woodward Governor Company of Rockford, Illinois, it is representative of a technological design standard for the period.

B. TECHNOLOGICAL EVOLUTION OF GOVERNANCE SYSTEMS FOR HYDROELECTRIC GENERATING PLANTS, ca. 1880-1945

A governor is a mechanism designed to regulate a turbine-generator unit at constant speed. It is an essential element of a hydroelectric plant due to the fact that unit speed determines the frequency of electric current produced. When fluctuations in power demand cause a change in turbine-generator speed, a governor responds by repositioning the gates that control the volume of water supplied to the turbine runner. The turbine gates are moved toward either the open or closed position as needed to maintain the balance between a unit's power input (in the form of water pressure) and power output (in the form of electric current). Thus, turbine-generator speed remains constant.

Early hydroelectric engineers initially adopted simple mechanical governors, which had frequently been used for waterwheel control since the early 1800s. In early mechanical governors, speed variation in a turbine-generator unit caused rotating flyballs to mechanically motivate a system of ratchet wheels and pawls which, in turn, slowly ratcheted turbine gates toward the open or closed position. Although widely used, mechanical governors generally rendered poor performance, especially at facilities that experienced dramatic changes in load. This was largely because of an inherent inability to adequately balance gate action and speed fluctuations. As a result, early mechanical governors often overshot gate movements, causing the unit to race and hunt.[1]

The need for precise turbine-generator speed control prompted a shift to oil-pressure (or less often water-pressure) governors equipped with anti-racing devices during the 1890s.[2] Like its mechanical counterpart, an oil-pressure governor relied on rotating flyballs to sense changes in turbine-generator speed. However, instead of activating gate motion directly, a shift in flyball position moved a distributing valve that controlled the flow of pressurized oil to either one or two cylinders known as servo-motors. When pressurized, the servo-motor(s) moved the turbine gate mechanism to the appropriate position. Gate movements immediately were transmitted from the servo-motor by rods and levers to a restoring mechanism or anti-racing device. Typically this was a dashpot which retarded flyball action so that the distributing valve returned to the neutral position. The repositioning of the distributing valve for each successive movement of the flyballs and gates smoothed operation of the actuator and prevented overtravel of the gates.[3]

The overall design of the governance system varied from plant to plant, depending, in part, on the number and capacity of the turbine-governor units. The flyballs, distributing valve, and dashpot typically were mounted in a stand configuration on the generating floor by the turbine-generator unit that it regulated. The flyballs were driven by the turbine-generator shaft via a system of gears and jack shaft, or belts and pulleys. They operated the distributing valve by means of floating levers and rods. Small capacity units often were equipped with a single servo-motor located in the base of the governor stand, while large units operated with two servo-motors mounted directly on the turbine casing. Oil for the system was pumped from a sump tank into a closed "pressure tank" where it was pressurized under a cushion of compressed air. Oil from the servo-motor discharged into the sump tank, where it was filtered before further use. Systems with three or fewer units commonly had an individual pressure tank, pump, and sump tank for each governor. A central sump tank and pumping system that serviced the entire governance system was the norm for larger plants.[4]

Oil-pressure governors remained standard hydroelectric practice until after World War II. During this era, however, engineers made significant improvements in their overall operation. By the early 1920s, for example, manufacturers had introduced governors with motor-driven flyballs as well as systems in which the flyballs were mounted directly on the turbine-generator shaft. These configurations eliminated belts and gearing that had required frequent adjustment and lubrication. Some other innovations of the period using a synchronized motor for speed adjustment after a unit had been brought on-line by hand and load limiting devices to prevent the governor from opening the turbine gates beyond a certain position regardless of turbine speed.[5] In the early 1930s, motor-driven flyballs that sensed speed fluctuations through a permanent magnetic generator (PMG) became standard practice. Because PMG flyball drive allowed the governor to be some distance from the turbine, governor manufactures soon offered "cabinet" governor stands that could be located almost anywhere on the generating floor.[6]

III. TECHNOLOGICAL DESCRIPTION OF THE RYAN GOVERNANCE SYSTEM

The governance system at the Ryan Hydroelectric Facility is original to the plant. It includes an oil-pressure type governor for each of the six turbine-generator units. Two governors of the same oil-pressure design but smaller in capacity also part of the system; each regulates one of the plant's turbine-generator excitor sets. The design and arrangement of the governors and their auxiliary elements are standard to the period. The system has sustain few alterations since installation.

Each governor stand is located on the generating floor next to the generator of the unit that it regulates (figure 1). Mounted on the stand are the flyballs in metal casing, the anti-racing device (dashpot), and distributing valve. The flyballs are pulley driven by the generator shaft. Each governor stand is complete with accessory components such as a hand control for gate operation independent of the distributing valve and dials indicating the position of the turbine gates and unit speed.

Each governor operates two servo-motors located in the turbine pit (see figure 1). The servo-motor are arranged on either side of the pit so that the connecting rods from each attach on opposites sides of an operating ring. One of the servo-motor pushes the operating ring in the direction that causes the turbine gates to move toward the open position, while the other servo-motor activates the gate mechanisms toward the closed position. A system of levers and rods translates gate movements to the dashpot.

Typical of most installations with more than three units, the oil-pressure system for the Ryan governors has an individual pressure tank for each unit but a centralized pumping system. A governor's pressure tank is by the stand on the generating floor (see figure 1). Each is a closed reservoir with gages indicating the oil volume and pressure mounted on the outside of the tank. Those for the main turbine-generator units are about 8 feet in height, while the pressure tanks at the excitor units are much smaller size and capacity. The common sump tank and pumps for the system are in the powerhouse basement adjacent to the turbine pits. The original pump and its motor-drive have been retired in-place. Two motor-drive replacement pumps now operate the oil-pressure system.

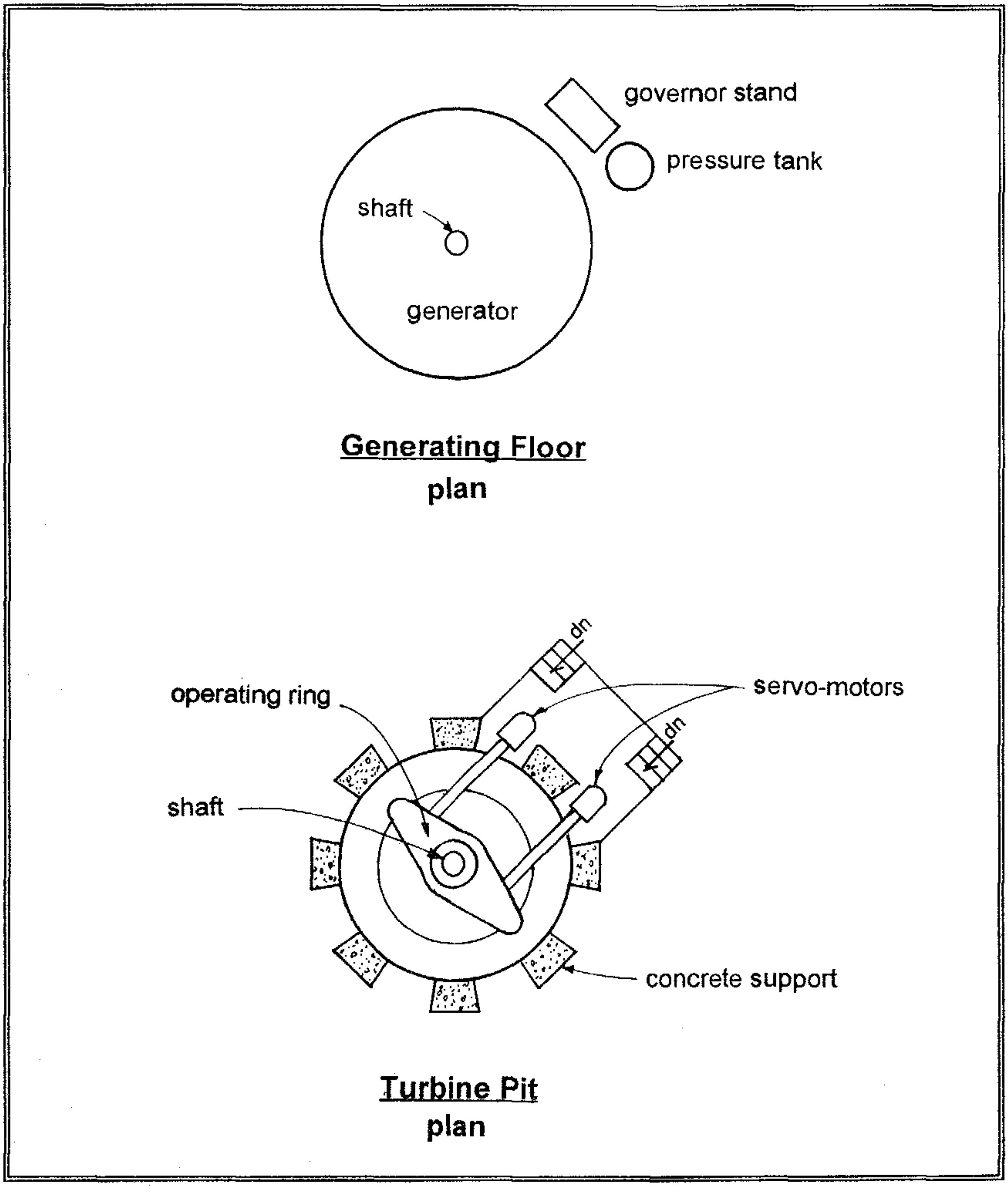

Figure 1. Plans Showing the Layout of Governance Equipment for a Turbine-Generator Unit.

IV. FUTURE OF THE RESOURCE

The Montana Power Company plans to replace the governance system at the Ryan Hydroelectric Facility (FERC Project No. 2188) with a modem equipment. The Company has sponsored recording the governance system to the standards of the Historic American Engineering Record.

V. ENDNOTES

1. Mark A. Repolgle, "Some Stepping Stones in the Development of a Modern Water-Wheel Governor," *Transactions of the American Society of Mechanical Engineers*, Paper 1110, 27 (1906): 646-647; N.L. Devendorf, "Speed Regulation in the Hydraulic Plant" *Power* 54 (15 November 1921): 765.

2. Replogle, "Some Stepping Stones," 644; and Duncan Hay, *Hydroelectric Development in the United States, 1880-1940*, vol. 1 (Washington, D.C.: Edison Electric Institute, 1991): 88.

3. Devendorf, "Speed Regulation in the Hydraulic Plant," 764-767; W.R. Kepler, "Hydraulic Turbine Governors," *Electric Journal* 65, no. 2 (February 1922): 60-62; H.G. Acres, "Modern Hydraulic Turbines of Large Capacity," *Mechanical Engineering* 45 (August 1923): 469; William P. Creager and Joel D. Justin, eds, *Hydro-Electric Handbook* (New York: John Wiley & Sons, Inc., 1927): 632.

4. Ibid.; F.H. Rogers, "Selection of Auxiliaries for Hydro-Electric Power Stations," *Power* 55 (16 May 1922): 775-776.

5. W.M. White, "Governors for Hydraulic Turbines," *Power Plant Engineering* 27 (1 December 1923): 1178-1182; William P. Creager and Joel D. Justin *Hydroelectric Handbook*, 2d ed. (New York: John Wiley & Sons, Inc., 1955): 898-899.

6. Hay, *Hydroelectric Development in the United States*, vol. 1, 89.

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